Amendments to the Specification:

Pursuant to 37 C.F.R. § 1.121(b) kindly amend the specification as follows. Amendments to the specification are made by presenting replacement paragraphs or sections marked up to show changes made relative to the immediate prior version. The changes in any amended paragraph or section are being shown by strikethrough (for deleted matter) or underlined (for added matter).

Please replace the FIELD OF THE INVENTION SECTION on page 1, lines 4-7 with the following FIELD OF THE INVENTION section, starting on page 1, line 4:

FIELD OF THE INVENTION

The invention pertains to the field of variable cam timing (VCT). More particularly, the invention pertains to a method for reducing VCT low speed closed loop excessive response time using error zero treatment.

Please replace the paragraph on page 4, lines 1-17 with the following paragraph, starting on page 4, line 1:

U.S. Patent No. 5,657,725 shows a control system which utilizes engine oil pressure for actuation. The system includes a~~A~~ camshaft with~~has~~ a vane secured to an end thereof for non-oscillating rotation therewith. The camshaft also carries a housing which can rotate with the camshaft but which is oscillatable with the camshaft. The vane has opposed lobes which are received in opposed recesses, respectively, of the housing. The recesses have greater circumferential extent than the lobes to permit the vane and housing to oscillate with respect to one another, and thereby permit the camshaft to change in phase relative to a crankshaft. The camshaft tends to change direction in reaction to engine oil pressure and/or camshaft torque pulses which it experiences during its normal operation, and it is permitted to either advance or retard by selectively blocking or permitting the flow of engine oil through the return lines from the recesses by controlling the position of a spool within a spool valve body in response to a signal indicative of an engine operating condition from an engine control unit. The spool is selectively positioned by controlling hydraulic loads on its opposed end in response to a signal

from an engine control unit. The vane can be biased to an extreme position to provide a counteractive force to a unidirectionally acting frictional torque experienced by the camshaft during rotation.

Please replace the paragraphs on page 4, line 27 through page 6, line 18 with the following paragraphs, starting on page 4, line 27:

U.S. Patent No. 6,-250,265 shows a variable valve timing system with actuator locking for internal combustion engine. The system comprising a variable camshaft timing system comprising a camshaft with a vane secured to the camshaft for rotation with the camshaft but not for oscillation with respect to the camshaft. The vane has a circumferentially extending plurality of lobes projecting radially outwardly therefrom and is surrounded by an annular housing that has a corresponding plurality of recesses each of which receives one of the lobes and has a circumferential extent greater than the circumferential extent of the lobe received therein to permit oscillation of the housing relative to the vane and the camshaft while the housing rotates with the camshaft and the vane. Oscillation of the housing relative to the vane and the camshaft is actuated by pressurized engine oil in each of the recesses on opposed sides of the lobe therein, the oil pressure in such recess being preferably derived in part from a torque pulse in the camshaft as it rotates during its operation. An annular locking plate is positioned coaxially with the camshaft and the annular housing and is moveable relative to the annular housing along a longitudinal central axis of the camshaft between a first position, where the locking plate engages the annular housing to prevent its circumferential movement relative to the vane and a second position where circumferential movement of the annular housing relative to the vane is permitted. The locking plate is biased by a spring toward its first position and is urged away from its first position toward its second position by engine oil pressure, to which it is exposed by a passage leading through the camshaft, when engine oil pressure is sufficiently high to overcome the spring biasing force, which is the only time when it is desired to change the relative positions of the annular housing and the vane. The movement of the locking plate is controlled by an engine electronic control unit either through a closed loop control system or an open loop control system.

U.S. Patent No. 6,-263,846 shows a control valve strategy for a vane-type variable camshaft timing system. The strategy involves an internal combustion engine that includes a

camshaft and hub secured to the camshaft for rotation therewith, where a housing circumscribes the hub and is rotatable with the hub and the camshaft, and is further oscillatable with respect to the hub and camshaft. Driving vanes are radially inwardly disposed in the housing and cooperate with the hub, while driven vanes are radially outwardly disposed in the hub to cooperate with the housing and also circumferentially alternate with the driving vanes to define circumferentially alternating advance and retard chambers. A configuration for controlling the oscillation of the housing relative to the hub includes an electronic engine control unit, and an advancing control valve that is responsive to the electronic engine control unit and that regulates engine oil pressure to and from the advance chambers. A retarding control valve responsive to the electronic engine control unit regulates engine oil pressure to and from the retard chambers. An advancing passage communicates engine oil pressure between the advancing control valve and the advance chambers, while a retarding passage communicates engine oil pressure between the retarding control valve and the retard chambers.

U.S. Patent No. 6,311,655 shows a multi-position variable cam timing system having a vane-mounted locking-piston device. An internal combustion engine having a camshaft and variable camshaft timing system, wherein a rotor is secured to the camshaft and is rotatable but non-oscillatable with respect to the camshaft is also described~~discribed~~. A housing circumscribes the rotor, is rotatable with both the rotor and the camshaft, and is further oscillatable with respect to both the rotor and the camshaft between a fully retarded position and a fully advanced position. A locking configuration prevents relative motion between the rotor and the housing, and is mounted within either the rotor or the housing, and is respectively and releasably engageable with the other of either the rotor and the housing in the fully retarded position, the fully advanced position, and in positions therebetween. The locking device includes a locking piston having keys terminating one end thereof, and serrations mounted opposite the keys on the locking piston for interlocking the rotor to the housing. A controlling configuration controls oscillation of the rotor relative to the housing.

Please replace the paragraphs on page 8, line 16 through page 9, line 5 with the following paragraphs starting on page 8, line 16:

Camshaft and crankshaft measurement pulses in the VCT system are generated by camshaft and crankshaft pulse wheels 22 and 24, respectively. As the crankshaft (not shown) and camshaft (also not shown) rotate, wheels 22, 24 rotate along with them. The wheels 22, 24 possess teeth which can be sensed and measured by sensors according to measurement pulses generated by the sensors. The measurement pulses are detected by camshaft and crankshaft measurement pulse sensors 22a and 24a, respectively. The sensed pulses are used by a phase measurement device 26. A measurement phase difference is then determined. The phase between a cam shaft and a crankshaft is defined as the time from successive crank-to-cam pulses, divided by the time for an entire revolution and multiplied by 360°~~. degree~~. The measured phase may be expressed as θ_0 16. This phase is then supplied to the control law 18 for reaching the desired spool position.

A control law 18 of the closed-loop 10 is described in United Patent No. 5,184,578 and is hereby incorporated herein by reference. A more detailed depiction of the control law along with a set point filter 30 is shown in Fig. 2. Measured phase 26 is subjected to the control law 18 initially at block 18a wherein a Proportional-Integral (PI) process occurs. PI process is the sum of two sub-processes. The first sub-process includes amplification; and the second sub-process includes integration. Measured phase is further subjected to phase compensation at block 18b, where the control signal is adjusted to increase the overall control system stability before it is sent out to drive the actuator, in the instant case, a variable force solenoid.

Please replace the paragraphs on page 9, line 21 through page 10, line 9 with the following paragraphs, starting on page 9, line 21:

Accordingly, in a VCT control system having a predetermined set point with a set point value and a set point filter filtering the set point and deriving a filtered set point value, the control system further has a control law for processing an error signal, a method is provided in which the method generates an error signal for reducing the excessive VCT response time caused by VCT undershooting its filtered set point. The method includes the steps of: providing an initial error; setting the initial error as the error subtracting a phase value from the set point value~~the set point value from a phase value~~ if a first set of conditions are met; and setting the difference of the above step as the error.

Accordingly, a VCT control system is provided which includes: a predetermined set point with a set point value; a set point filter filtering the set point and deriving a set point value; a control law for processing an error signal derived in part from the set point filter; and an error zero treatment block having the set point value and the filtered set point value. The error zero treatment block includes a method that generates an error signal for reducing the excessive VCT response time caused by VCT undershooting its filtered set point. The method includes the steps of: providing an initial error; setting the initial error as the error subtracting a phase value from the set point value ~~the set point value from a phase value~~ if a first set of conditions are met; and setting the difference of the above step as the error.

Please replace the paragraphs on page 11, lines 1-19 with the following paragraphs starting on page 11, line 1:

Scenario A: When the VCT phase response -61 has overshot the filtered set point 13, but not the set point 12 (i.e., in the area interposed between the set point 12 curve and the filtered set point curve), ~~the~~ maintaining ~~of~~ the VCT motion is desirable. In other words, reducing the time lap is desirable. The VCT motion is defined as the movement of a phaser such as the oscillation of at least one vane therein maintaining the current direction toward a predetermined set point. However, the VCT controller (not shown) actually pulls the VCT rotor back towards the filtered set point 13, and causes the VCT to undershoot the filtered set point 13. The response time (which is defined as the time between a set point change and the VCT reaches its commanded position) is prolonged. See (1) in Figs. 5 and 5A, where Fig. 5A is a blown up view of portions of Fig. 5.

A phase response is defined as a dynamic state, or the phaser motion following a control action. Using an analogy, the step response of a R-C circuit is the response during the dynamic state (change of current and voltage in the time domain) of a R-C circuit after applying a voltage to the circuit.

Scenario B: When the VCT phase 61 has overshot the set point 12 and the filtered set point 13 has not reached its steady state value, pulling the VCT 61 towards the set point 12 is enough. However, the VCT controller pulls the VCT 61 towards the filtered set point 13, which

is more than required. This pulling of the VCT 61 towards the filtered set point 13 is undesirable in that response time is lengthened. See region (4) in Fig. 5.

Please replace the paragraph on page 12, lines 8-17 with the following paragraph starting on page 12, line 8:

Fig. 4 is a flow chart 50 which shows the added Error Zero Treatment block 40 of Fig 3. Initial block 52 set treated E0 using the current or present E0. If the conditions in block 54 occur, i.e. if set point 12 value is greater than the filtered set point 13 value and phase 61 value is greater than filtered set point 13 value, the E0 is subjected to another condition of block 56. At this juncture, if phase 61 value is greater than set point 12 value, the new E0 or the treated E0 is set to be the value resulting from a difference of set point 12 value minus the phase 61 value. Otherwise, set the new E0 to zero. In other words, if phase 61 value is less than set point 12 value, set treated E0 to zero. The resultant E0 is subject to further treatment at block 62. If the conditions in block 54 are not met or do not occur, the E0 of block 52 is maintained and subject to further treatment at block 62.

Please replace the paragraph on page 13, lines 12-15 with the following paragraph starting on page 13, line 12:

The introduction of the E0 treatment cause the phase value 61 at the start of segment 61a to be set to set point value 12 instead of filtered value 13. Thereby, curve 61 is set to the corresponding value of curve 12, instead of being commanded to meander around the proximity of curve 13~~,~~. This action can be depicted by the arrow 74.

Please replace the paragraph on page 15, lines 16-31 with the following paragraph, starting on page 15, line 16:

One embodiment of the invention is implemented as a program product for use with a computer system such as, for example, the schematics shown in Fig 3 or a suitable engine control unit (ECU) and described below. The program(s) of the program product defines functions of the embodiments (including the methods described below with reference to Fig. 4) and can be contained on a variety of signal-bearing media. Illustrative signal-bearing media include, but are not limited to: (i) information permanently stored on in-circuit programmable devices like

PROM, EPPOM, etc; (ii) information permanently stored on non-writable storage media (*e.g.*, read-only memory devices within a computer such as CD-ROM disks readable by a CD-ROM drive); (iii) alterable information stored on writable storage media (*e.g.*, floppy disks within a diskette drive or hard-disk drive); (iv) information conveyed to a computer by a communications medium, such as through a computer or telephone network, including wireless communications, or a vehicle controller of an automobile. Some embodiments specifically include~~s~~ information downloaded from the Internet and other networks. Such signal-bearing media, when carrying computer-readable instructions that direct the functions of the present invention, represent embodiments of the present invention.

Please replace the paragraphs on page 16, line 9 through page 19, line 3 with the following paragraphs, starting on page 6, line 9:

It is noted the hydraulic fluid or fluid referred to supra are actuating fluids. Actuating fluid is the fluid which moves the vanes in a vane phaser. Typically the actuating fluid includes engine oil, but could be separate hydraulic fluid. The VCT system of the present invention may be a Cam Torque Actuated (CTA) VCT system in which a VCT system that uses torque reversals in camshaft caused by the forces of opening and closing engine valves to move the vane. The control valve in a CTA system allows fluid to flow from an advance chamber to a retard chamber, allowing the vane to move, or stops flow, locking the vane in position. The CTA phaser may also have oil input to make up for losses due to leakage, but does not use engine oil pressure to move phaser. A v~~V~~ane is a radial element actuating fluid acts upon, housed in a chamber. A vane phaser is a phaser which is actuated by vanes moving in chambers.

There may be one or more camshaft per engine. The camshaft may be driven by a belt or chain or gears or another camshaft. Lobes may exist on the camshaft to push on valves. In a multiple camshaft engine, most often has one shaft for exhaust valves, one shaft for intake valves. A "V" type engine usually has two camshafts (one for each bank) or four (intake and exhaust for each bank).

A c~~C~~hamber is defined as a space within which the vane rotates. The ch~~C~~amber may be divided into an advance chamber (makes valves open sooner relative to the crankshaft) and a retard chamber (makes valves open later relative to the crankshaft). A c~~C~~heck valve is defined

as a valve which permits fluid flow in only one direction. A closed loop is defined as a control system which changes one characteristic in response to another, then checks to see if the change was made correctly and adjusts the action to achieve the desired result (e.g. moves a valve to change phaser position in response to a command from the ECU, then checks the actual phaser position and moves valve again to correct position). A c~~C~~ontrol valve is a valve which controls the flow of fluid to the phaser. The control valve may exist within the phaser in CTA system. The c~~C~~ontrol valve may be actuated by oil pressure or a solenoid. A c~~C~~rankshaft takes power from pistons and drives transmission and camshaft. A s~~S~~pool valve is defined as the control valve of spool type. Typically the spool rides in bore, connects one passage to another. Most often the spool is most often located on center axis of rotor of a phaser.

A d~~D~~ifferential Pressure Control System (DPCS) is a system for moving a spool valve, which uses actuating fluid pressure on each end of the spool. One end of the spool is larger than the other, and fluid on that end is controlled (usually by a Pulse Width Modulated (PWM) valve on the oil pressure), full supply pressure is supplied to the other end of the spool (hence *differential* pressure). A v~~V~~alve Control Unit (VCU) is a control circuitry for controlling the VCT system. Typically the VCU acts in response to commands from ECU.

A d~~D~~riven shaft is any shaft which receives power (in VCT, most often a camshaft). A d~~D~~riving shaft is any shaft which supplies power (in VCT, most often a crankshaft, but could drive one camshaft from another camshaft). The ECU is an Engine Control Unit that is the car's computer. Engine Oil is the oil used to lubricate engine, pressure can be tapped to actuate phaser through the control valve.

The h~~H~~ousing is defined as the outer part of the phaser with chambers. The outside of the housing can be a pulley (for a timing belt), a sprocket (for a timing chain) or a gear (for a timing gear). Hydraulic fluid is any special kind of oil used in hydraulic cylinders, similar to brake fluid or power steering fluid. Hydraulic fluid is not necessarily the same as engine oil. Typically the present invention uses "actuating fluid". A l~~L~~ock pin is disposed to lock a phaser in position. Usually the lock pin is used when oil pressure is too low to hold the phaser, as during engine start or shutdown.

An Oil Pressure Actuated (OPA) VCT system uses a conventional phaser, where engine oil pressure is applied to one side of the vane or the other to move the vane.

An o~~O~~pen loop is used in a control system which changes one characteristic in response to another (say, moves a valve in response to a command from the ECU) without feedback to confirm the action.

Phase is defined as the relative angular position of the camshaft and the crankshaft (or a camshaft and another camshaft, if the phaser is driven by another cam). A phaser is defined as the entire part which mounts to cam. The phaser is typically made up of a rotor and a housing and possibly a spool valve and check valves. A piston phaser is a phaser actuated by pistons in cylinders of an internal combustion engine. The r~~R~~otor is the inner part of the phaser, which is attached to a cam shaft.

Pulse-width Modulation (PWM) provides a varying force or pressure by changing the timing of on/off pulses of current or fluid pressure. A s~~S~~olenoid is an electrical actuator which uses electrical current flowing in a coil to move a mechanical arm. A v~~V~~ariable force solenoid (VFS) is a solenoid whose actuating force can be varied, usually by PWM of supply current. A VFS is opposed to an on/off (all or nothing) solenoid.

A s~~S~~procket is a member used with chains such as engine timing chains. Timing is defined as the relationship between the time a piston reaches a defined position (usually top dead center (TDC)) and the time something else happens. For example, in VCT or VVT systems, timing usually relates to when a valve opens or closes. Ignition timing relates to when the spark plug fires.

Torsion Assist (TA) or Torque Assisted phaser is a variation on the OPA phaser, which adds a check valve in the oil supply line (i.e. a single check valve embodiment) or a check valve in the supply line to each chamber (i.e. two check valve embodiment). The check valve blocks oil pressure pulses due to torque reversals from propagating back into the oil system, and stops the vane from moving backward due to torque reversals. In the TA system, motion of the vane due to forward torque effects is permitted; hence the expression "torsion assist" is used. Graph of vane movement is step function.

A VCT system includes a phaser, control valve(s), control valve actuator(s) and control circuitry. Variable Cam Timing (VCT) is a process, not a thing, that refers to controlling and/or varying the angular relationship (phase) between one or more camshafts, which drive the engine's intake and/or exhaust valves. The angular relationship also includes a phase relationship between the cam and the crankshafts, in which the crank-shaft is connected to the pistons.